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Albizia lebbek (L.) Benth Siris

Leguminosae (Mimosaceae) Legume family

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HABITAT

Native Range

Albizia lebbek (L.) Benth., the siris tree, is a fast-growing, medium-sized deciduous tree commonly found in both dry and moist forests in its native Asian range. Its natural range extends from latitudes 8° N. to 32° N. through eastern Pakistan, India, Sri Lanka, Bangladesh, and Burma (*50*). Siris has been widely used throughout the tropics and northern subtropics as an ornamental and grown in plantation systems; it has become naturalized in Southeast Asia, the Malay peninsula and archipelago, Indonesia, Papua New Guinea, northern Australia, Afghanistan, Iran, Iraq, Egypt, west Africa, throughout the Greater and Lesser Antilles, El Salvador, Belize, Colombia, Venezuela, and Brazil (*1, 21, 25, 31, 53*). Within its native south Asian range, siris is a well-known and widely used component of natural forests and village lands. In India alone there are over 45 common names (*6, 14, 17, 47, 51*); in the tropical regions of North and South America there are over 23 common Spanish names (*31, 32, 41, 42*).

Siris is characterized by a spreading umbrella-shaped crown of thin foliage; bipinnately compound leaves 15 to 40 cm long with small, but conspicuous, extrafloral nectaries at the base of both the petioles and main rachis (*40*); sweetly fragrant greenish- or yellowish-white, clustered, hairy-stalked flowers; flattened seed pods 12 to 25 cm long; and smooth gray or grayish-brown bark (*32*). Open-grown trees attain heights of 15 m with stem diameters of 2 to 3 m or greater. In dense natural stands or plantations the tree produces a long, straight bole and may reach 25 to 30 m in height (*47, 51*).

Climate

Siris occurs in a variety of tropical and subtropical climates. It can be found in tropical and subtropical dry, moist and wet forest life zones, where annual precipitation ranges from 500 to 2500 mm with or without a pronounced dry season (*47, 50*). Its native north Indian range, for example, is characterized by hot, dry summers and cold winters, with mean daily temperatures ranging from 5 to 46 °C. The species is reported to be tolerant of both drought and frost (*47, 50*).

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Soils and Topography

Siris grows well on a variety of soils, but it grows best on moist, well-drained loams at altitudes from 0 to 1500 m above sea level. Although it does not normally grow well on heavy clay soils, siris can tolerate lateritic, saline and sodic conditions (*4, 46*). Good performance has been reported in rocky limestone soils and alkaline calcareous sands (*8, 12, 40, 50*). Its tolerance of sea spray makes siris a suitable species for reforestation in coastal areas. Siris readily forms a symbiotic association with *Rhizobium* (*2, 5, 30*), and the resulting nitrogen-fixing capacity enables it to thrive in nitrogen deficient soils. All these properties increase the adaptability of siris to marginal sites.

Associated Forest Cover

Albizia lebbek is a pioneer species in a variety of forest types, including dry and moist mixed deciduous forests and moist semievergreen and evergreen forests. In the latter forests, individuals are usually scattered (*50*).

In the Andaman Islands, siris is commonly found in the low-elevation *Pterocarpus dalbergioides* Roxb.-dominated deciduous forest, and it can be found as a canopy codominant in the *Dipterocarpus*-dominated moist evergreen forest (*47, 50*).

In tropical dry and dry mixed deciduous forests of India, siris is commonly associated with the dominant species *Hardwickia binata* Roxb. and *Tectona grandis* L. f., particularly in moist ravines and along streambanks (*50*). In West Bengal (India) and in Bangladesh, siris is usually associated with *Salmalia malabarica* (DC.) Schott. & Endl., *Hymenodictyon excelsum* Wall., *Adina cordifolia* Hook. f., *Trewia nudiflora* Linn., *Erythrina* spp., *Dalbergia stipulacea* Roxb., *Crataeva unilocularis* Ham., and *Tetrameles nudiflora* R. Br. in open forest (*50, 52*). In the dry, deciduous scrub forests of southern India, where annual precipitation is approximately 750 mm, *Albizia lebbek* occurs with *Santalum album* Linn., other *Albizia* species, as well as members of the genera *Acacia, Tamarindus, Zyziphus, Cassia, Terminalia, Pterocarpus, Pongamia, Phyllanthus*, and *Anogeissus* (*9*). Siris also occurs as an invasive species in the dry plain forests of Punjab dominated by *Prosopis spicigera* L., *Salvadora oleoides* Dcne., and *Capparis decidua* (Forsk.), particularly following improvement of soil moisture conditions (*50*).

LIFE HISTORY

Reproduction and Early Growth

Flowering and Fruiting.—Flowering generally coincides with the increase of new leaf growth following the dry season, usually between March and May in northern India and

between April and September in the Caribbean region. As early as the first growing season, flowering has been observed on trees as small as 1 m in height with stem diameters of 3 cm or greater. Flowers occur in rounded clusters (umbels) borne at the end of lateral stalks 4 to 10 cm long. Individual flowers (3 to 4 cm long) have a tubular five-toothed hairy calyx 3 mm long; a narrow, tubular, white corolla 8 mm long; numerous whitish-yellow and pale green threadlike spreading stamens; and a pistil of narrow ovary and threadlike style (*32*). Wind appears to be the principal pollen vector, but the fragrant flowers do attract large numbers of bees, which are likely to contribute to pollination.

The fruits, flattened pods 12 to 20 cm long and 2 to 5 cm wide, are produced in large numbers and may remain green until November. The mature straw-colored pods, each containing 6 to 12 seeds, remain attached to the tree during the winter months, when most or all of the leaves have been shed. The pods continue well into the following flowering season (*31, 47*). Seeds are readily extracted either by opening or crushing the pods by hand and separating them by winnowing (*47*).

Seed Production and Dissemination.—Siris seeds are small (7-11 by 6-9 mm; 7000-11000/kg), oblong, compressed, and light brown in color with a smooth, hard testa. Seeds may be released from mature dehiscent pods that are still attached to the tree, or they may be released from windblown pods that later dehisce or decompose. Under natural conditions, insect attack is responsible for high seed predation. In India, the principal seed predators include the larvae of the lepidopteran *Stathmopoda basiflectra* Meyrick and larvae of the coleopterans *Bruchus pisorum* Linn., *B. saunersi* Jekel, and *B. sparsemaculatus* Pic. (*50*). In Puerto Rico, seeds are particularly susceptible to attack by bruchid beetle larvae that emerge from eggs laid in ripened fruits by the adult (*40*).

Seedling Development.—Germination in siris takes place on the soil surface. The seeds may be sown without treatment. However, soaking the seeds in boiling water for 1 minute, followed by cool water for 24 hours, is reported to facilitate germination.

Germination of freshly extracted seeds obtained in Puerto Rico was 60 to 90 percent; after 1 year of cold storage at 5 to 10 °C, germination dropped to a mean of 12 percent (*40*). In the same study, germination under light shade occurred 4 to 20 days following sowing, with peak germination between 12 and 18 days. Reports from India, however, indicate more rapid germination and higher germination percentages for seeds stored at room temperature for 2 to 4 years than freshly extracted seed (*47, 50*). Viability of stored seeds is reportedly very high, with little loss of germinative capacity for at least 5 years following collection (*47*).

Under natural regeneration conditions, germination begins early in the rainy season. Germination percentage is normally very low under natural conditions, primarily due to seed predation (*50*). Loose, moist soil and light shade or full sunlight favor germination and early seedling development. Seedlings do not tolerate heavy shade (*47, 50*).

Seedlings are not very sensitive to frost, but they are somewhat sensitive to drought. High seedling mortality has been reported when dry weather occurs during or shortly after germination. Under these conditions, the presence of grasses or light weed growth is helpful in preventing drought mortality, although competing vegetation may impede development (*47*). At a coastal site in Puerto Rico, 73 percent of the seedlings planted at the commencement of the dry season suffered serious dieback during the first 2 months following establishment (*40*). This was attributed to drought stress during the critical establishment phase. Yet 97 percent of these seedlings recovered quickly after rains commenced, producing new shoots from axillary buds below the dieback point or from the stem base.

Under nursery conditions, seedling growth is enhanced by absence of weeds, loose soil, sufficient soil moisture, and full sunlight. Moderate shade is tolerated (*40*). Suppression is not well tolerated; when crowded, the more vigorous seedlings quickly suppress the weaker ones (*47*). In south Asia, seeds may be sown from March through April in rows at least 20 cm apart, with the beds kept well-weeded and watered regularly but moderately. The young plants may be transplanted early in the rainy season (June through July) (*47, 50*). In Puerto Rico, seedlings raised in plastic sleeves under light shade and watered regularly were ready for transplanting at 3 months (*40*).

Seedlings produce a long, stout taproot at an early age, which may reach 70 cm in length after 4 months. Lateral roots are often covered with rather large *Rhizobium* nodules (*40, 47*). Nodulation in siris seedlings by native *Rhizobium* is rapid in both unsterilized and sterile soil; treatment with rhizobial isolates also results in rapid nodulation (*5*).

Plantations may be established by direct sowing, planting of seedlings, stem or root cuttings, and stumps (*24, 37, 47, 50*). In India, direct sowing has been found preferable to transplanting, as the latter deters growth to some extent (*47*). Transplanting can be successfully carried out either by pruning the root and stem or leaving them intact. Because of the length of the taproot, in the latter case it is advisable to use small plants during the first rainy season (*40, 47*). If pruning is carried out, the stem should be cut down to about 5 cm from ground level and the taproot pruned to a length of about 22 cm (*47*).

Vegetative Reproduction.—Siris seedlings, saplings, and larger trees all coppice vigorously when damaged; vegetative reproduction also occurs through layering (*40*). Root suckers are readily produced when roots are exposed (*43, 47*). Viable shoot buds have been produced through tissue culture from hypocotyl, root, cotyledon, and leaflet explants (*18, 44*).

Sapling and Pole Stage to Maturity

Growth and Yield.—Siris is widely recognized as an excellent species for reforestation on disturbed or degraded sites (*28, 31, 37, 38*). Siris is suitable for afforestation in coastal, moderately dry, and semiarid regions and also performs well on alkaline and saline soils (*8, 19, 28, 31*). Its rapid early growth, excellent coppicing ability, site adaptability, and nitrogen-fixing capacity have made it a popular species for fuelwood plantations and agro-forestry systems in south Asia, west Africa, and tropical regions of North, Central, and South America (*26, 31, 36, 37, 38, 41*).

Average height growth at 24 months under plantation conditions in Puerto Rico was 2.1 and 3.4 m at stocking rates of 40,000 and 2,500 trees/ha, respectively (*40*). In India, average reported height growth ranged from 4.6 to 5.9 m at 6 years and 5.1 to 18 m at 9 years (*19, 50*). Average maximum height ranges from 18 to 25 m (*29, 47, 50*).

Tree form is greatly affected by stand density. Under open-grown or widely spaced plantation conditions, trees tend to fork or branch near the base of the stem, resulting in poor tree form (*29, 40*).

Diameter growth is highly variable within even-aged plantations (*19, 40, 47, 50*). This variability is partially explained by competition effects, variable soil fertility and soil moisture, and high genetic variability (*40*). In Puerto Rico, mean stem diameter at 24 months ranged from 2.5 to 6.6 cm at plantation stocking rates of 40,000 to 2,500 trees/ha, respectively (*40*). In India, average stem diameter in plantations ranged from 8.3 to 10.2 cm at 6 years, 10 to 20 cm at 9 years, 26 to 80 cm at 12 years, and 44 to 140 cm at 30 years (*47, 51*).

In Indonesia, stem volumes of 34 to 51 m^3/ha at 10 and 12 years, respectively, have been reported (*50*). In India, mean annual volume increments ranging from 5.0 to 8.4 m^3 have been reported for plantations managed in rotations of 10 to 15 years or more (*38, 51*). In the arid zone of western Rajasthan (India), optimal rotation length for rain-fed plantations has been reported as 11 to 14 years (*27*). Total aboveground biomass of 12.6 to 17.4 mg/ha at 24 months has been reported in rainfed plantations in Puerto Rico (*40*), and 22 and 53 mg/ha at 2 and 3 years, respectively in irrigated plantations in India (*23*).

In hedge-cropping trials conducted in the Virgin Islands, mean annual yields of 15.6 mg/ha total aboveground biomass and 2200 kg/ha protein were reported over a 5-year period for closely spaced hedges cut three to four times per year, beginning 5 months after sowing (*39*).

Siris has been grown in mixed plantations with *Casuarina equisetifolia* L. in India, with casuarina at an initial spacing of 2.75 by 2.75 m and siris at 5.5 by 5.5 m. Casuarina was felled at 7 to 9 years, allowing siris development to continue for several more years; at 10 years, trees attained a mean height of 18 m and a maximum girth of 66 cm (*50*). The species has also been raised in south Asia using the Taungya system and in conjunction with field crops (*50*).

Rooting Habit.—Siris generally forms a wide spreading lateral root system; however, because the root system is largely superficial, trees tend to be susceptible to windthrow. In well-drained soils or in arid conditions, a deep taproot also develops (*35, 40, 47, 50*).

In Puerto Rico, root biomass ranged from 40 to 70 percent of total biomass for trees with basal diameters ranging from 0.5 to 17.0 cm; in this study, the proportion of root biomass to total biomass was found to be inversely correlated with both tree size and local soil moisture-holding capacity (*40*). For dominant trees in 3-year-old plantations in India, root biomass was found to comprise 25 percent of the total (*23*).

Reaction to Competition.—Siris is intolerant of dense shade and does not grow well under its own canopy (*40, 47, 50*). In dense stands, siris growth is slowed. In Puerto Rico, aboveground biomass yields at 24 months in plots planted at 0.5 m, 1.0 m, and 2.0 m spacings increased from 12.6 to 17.4 mg/ha with increasing stand density; average tree size, however, was greatly reduced at higher stocking rates (*40*). The same study showed direct, positive correlations between stand density and self-pruning of branches. Improved tree form, therefore, develops at higher stocking rates.

Damaging Agents.—Siris is reportedly susceptible to insect attack under plantation conditions in India, particularly in the Andaman Islands. The principal insect pests in India include the hemipteran *Oxyrhachis tarandus* Fabr. (Membracidae), which attacks the young shoots of seedlings and saplings, and the larvae of the lepidopterans *Eurema blanda-silhetana* Wallace and *E. hecabe* Linn., which defoliate by feeding on young leaves. The larvae of the coleopterans *Xystrocera festiva* and *X. globosa* Olivier, which feed on the inner bark and sapwood of siris trees in tea gardens in Burma, Malaysia, and Java, have been reported to hasten the death of less vigorous trees. *Xystrocera globosa* Olivier is reported to be responsible for the disappearance of siris avenue plantings in several cities in Egypt (*50*). Approximately 60 other coleopteran, hemipteran, homopteran, and lepidopteran insect pests of unknown importance have been reported to feed on young shoots, leaves, roots, sap, seeds, and dead wood of siris in south and Southeast Asia (*7, 34, 45*).

Several fungi have been reported as leaf and stem diseases of siris (*20*). *Endodothella albiziae* (Syd.) von Arx and *E. deightonii* (Syd.) von Arx infect the leaves, causing numerous small yellow spots on which the fruiting structures appear as minute black dots. *Endodothella albiziae* has been reported in Africa, Pakistan, and the Philippines, while *E. deightonii* is confined to Africa and south Asia. *Camptomeris albizae* (Petch) Mason is a weak pathogen associated with foliar necrosis of siris in Africa, south Asia, and the Dominican Republic. *Helminthosporium albiziicola* Thirum & Naras. is a similar fungus forming brownish pustules on reddish leaf spots on siris in India. *Colletotrichum lebbek* (Syd.) Petrak has been collected from seed pods in Pakistan, the Philippines, and Jamaica. The powdery mildew *Leiveillula taurica* (Lev.) Arnaud has been found on siris in Pakistan, where it causes leaf necrosis accompanied by characteristic white powdery superficial growth of the fungus.

Various unimportant rusts have been known to attack *A. lebbek*. These include *Sphaerophragmium acaciae* (Cooke) Magnus (in west Africa, south and Southeast Asia, and the United States), *Ravenelia sessilis* Berk. (in south Asia and China), and *Uredo* spp. (in east Africa and India). The fungus *Nectria ditissima* Tul. has been reported as the cause of bark-cracking at the base of the stem, which results in leaf-shedding and dieback. *Phomopsis mendax* (Sacc.) Trav. has been associated with dieback in south Asia.

Siris is also susceptible to a vascular wilt caused by *Fusarium oxysporum* Schl. f. sp. *perniciosum* (Hept.) Toole, which is perhaps the most important fungal disease of *Albizia* spp. The fungus invades the fine roots, causing a gummosis of the vessels; wilting and death of the host follows within a year of infection. Spread of the pathogen is mainly by transfer of infected soil; the fungus rarely sporulates on the host. The following fungi have been recorded as the cause of heart and butt rot in siris: *Phellinus fastuosus* (Lev.) Ryv., *P. gilvus* (Schw.) Pat., and *Flavodon flavus* (Kl) Ryv. (*20*).

Because the foliage of this species is highly palatable, it is subject to browsing by livestock, deer, camels, and elephants (*6, 41, 47, 50*).

SPECIAL USES

In India, Southeast Asia, and Colombia, siris is used as a shade tree in plantations of coffee, tea, cardamom, and cacao (*22, 41, 50*); in Kerala (south India), it is planted as a source of green manure for paddy crops (*50*). Siris is also pollarded and

used as a host for the lac insect in India; the lac produced is very similar to that produced when *Ficus religiosa* Linn. (pipal) is used as the host tree. (*33, 50*). The tree is reported to be a good producer of honey (*26, 31*).

Several wood properties of this species make it an excellent furniture wood. The light yellowish heartwood is moderately hard (specific gravity: 0.55-0.60), coarse-grained, strong, and fairly durable. It seasons and works well, and polishes easily (*32, 51*). During the early 20th century, high quality siris timber was exported to Europe from the Indian subcontinent under the trade name of "East Indian walnut" (*2, 47*). In south Asia, the wood is used for a variety of purposes, including carts, boats, furniture, parquet and strip flooring, veneers, paneling, carving, posts, the manufacturing of agricultural implements, rollers, wheels, and sugarcane crushers. The burls are particularly valuable for carving and turning (*6, 15, 50, 54*). The wood is also an excellent fuel, either as firewood or charcoal, and is used throughout the tree's range for this purpose. The heartwood caloric content is 5.17 Kcal/g (*51*).

In addition, secondary products can be obtained from the stem and bark of this species. When injured, the stem exudes a reddish-brown gum that is used as a substitute for gum arabic (from *Acacia senegal* Willd.) (*16, 37*); the bark contains 5 to 15 percent tannin and is used in India for tanning and dyeing. Its high saponin content has led to its use as a detergent (*48, 49*).

Because the leaves and twigs contain up to 30 percent protein and are a favorite of cattle, elephants, camels, and goats, the species is an excellent fodder source (*26, 37, 47*).

Siris is also used extensively in traditional Indian medicine (*11*). The leaves are used in the treatment of eye ailments, particularly night blindness (*6, 10, 22*). The bark is used for the treatment of skin diseases, bronchitis, toothaches, and rat bites. The root is astringent and is a remedy for eye troubles and headaches (*6*). The seeds, which also have astringent properties, are used to treat hemorrhoids and diarrhea. All parts of the tree are used to treat the bites of venomous animals (*6*). The leaves are known to have insecticidal properties (*10*).

In its native south Asian range, siris has important symbolic value among certain communities. Hindus, for example, value the flowers for religious ceremonies (*6*), and Buddhists hold the tree sacred (*3*).

GENETICS

Albizia is a large and complicated pantropical genus of 150 species, mostly trees and shrubs. Species are most numerous in the Old World tropics. They are closely related to and often mistaken for *Acacia* species (*2*).

Most species in the genus are well adapted to poor soils and are common in low bush, secondary forest, savannas, and along sandy riverbeds up to 1600 m elevation. *Albizia falcataria* (L.) Fosberg, formerly known as *Albizzia falcata* (L.) Backer and *A. moluccana* Miq., is one of the fastest growing trees in the world and is widely cultivated in Southest Asia and the Pacific as a source of timber, pulpwood, and fuelwood. *Albizia falcataria* grows well only in the wet tropics where rainfall is 2000 to 2700 mm/yr. On good sites with adequate rainfall, its productivity is greater than that of *A. lebbek*, with mean annual increments of 25 to 40 m^3/ha in an 8- 12-year rotation (*37*).

Other promising species with growth characteristics and wood properties similar to *A. lebbek* include *A. chinensis* (Osb.) Merr. and *A. procera* (Roxb.) Benth., both native to south and Southeast Asia, as well as *A. adianthifolia* (Schum.) W.F. Wight, *A. ferruginea* (Guill. & Perr.) Benth., *A. gummifera* (J.F. Gmel.) C.A. Sm., and *A. zygia* (DC.) Macbride, all native to Africa. Aside from *A. lebbek* and *A. falcataria*, most species of this genus remain largely untested under plantation conditions (*37*).

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